


A satellite image of Earth showing North and Central America, the surrounding oceans, and parts of South America and Africa. The image is centered on the Americas, with the Atlantic Ocean to the east and the Pacific Ocean to the west. The text is overlaid on the image.

# **Earth's Energy Budget: A Story**

**NASA Langley Research Center  
2013**



Most of the energy on Earth  
comes to us from the Sun.


Did you know?: The amount of sunlight that reaches the Earth is equal to approximately 660w light bulbs for every square meter of the surface.

approximately 660w light bulbs for every square meter of the surface.  
Did you know?: The amount of sunlight that reaches the Earth is equal to

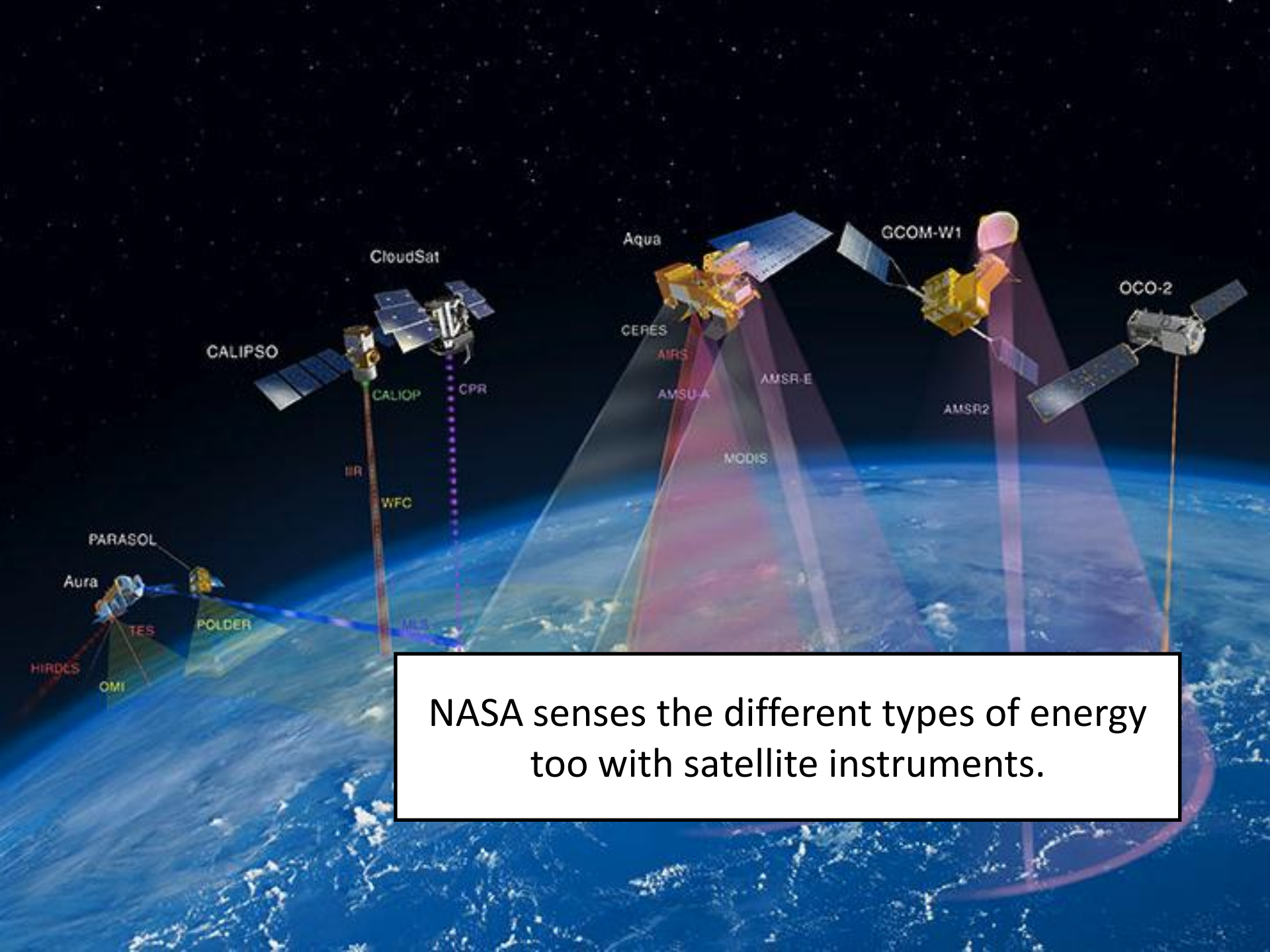


We can sense that energy in different ways. We see the things around us because of visible light...



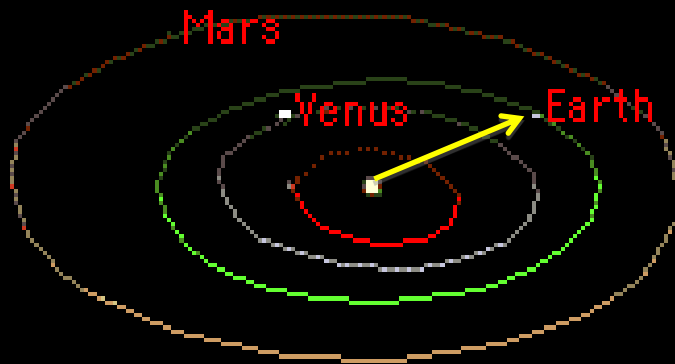


... And we feel the heat  
from a campfire, which is  
infrared energy.



NASA senses the different types of energy too with satellite instruments.

If all of these types of energy from the Sun are always shining down on Earth, how does the Earth manage to maintain the perfect balance of energy – or equilibrium – that allows us to live and survive on Earth?

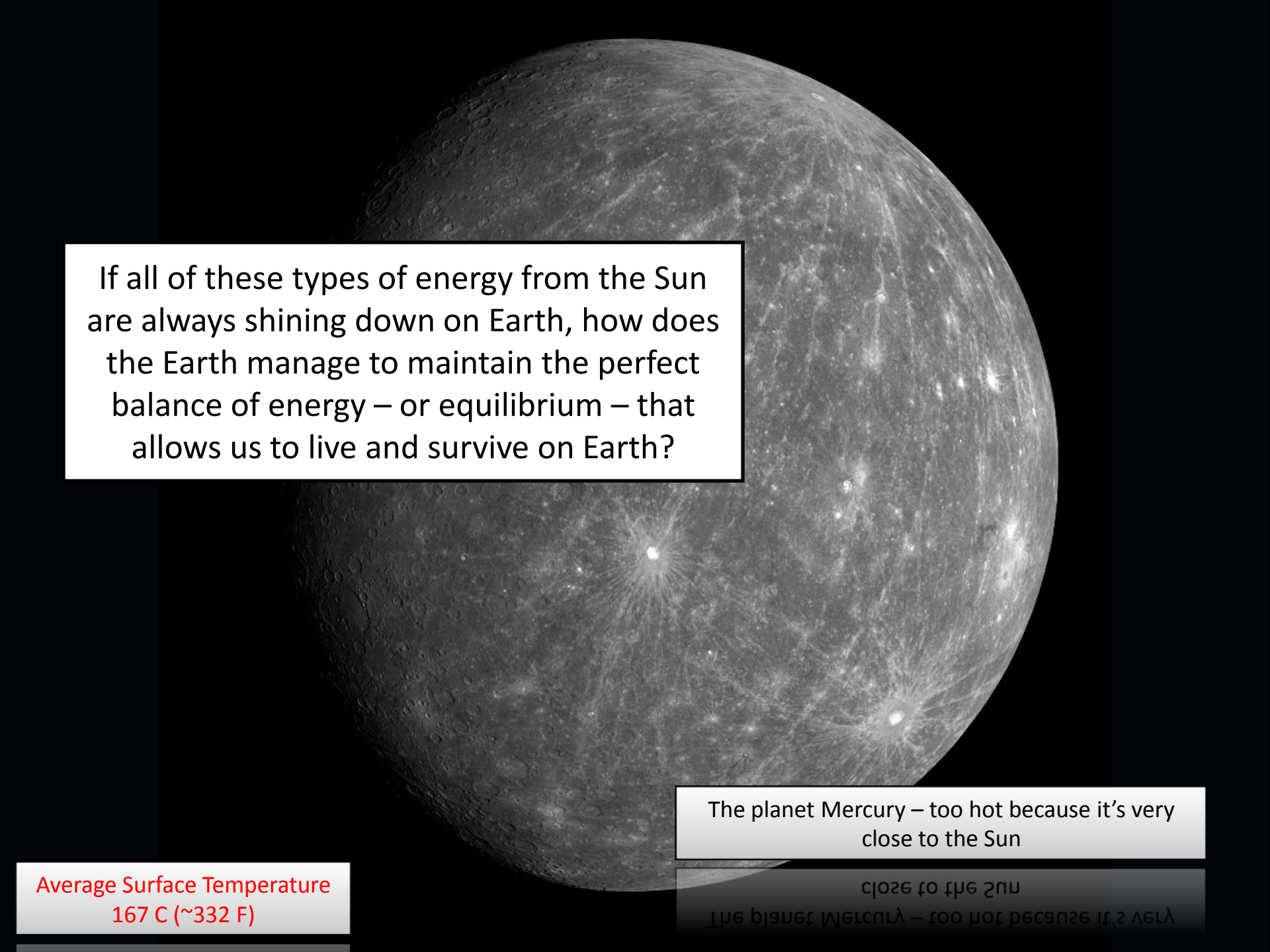


Jupiter

The Sun – hot though it is - is a tiny part of Earth's environment. The rest is cold, dark space.

environment. The rest is cold, dark space.  
The sun – hot though it is - is a tiny part of Earth's






If all of these types of energy from the Sun are always shining down on Earth, how does the Earth manage to maintain the perfect balance of energy – or equilibrium – that allows us to live and survive on Earth?

Average Surface Temperature  
167 C (~332 F)

The planet Mercury – too hot because it's very close to the Sun

The planet Mercury – too hot because it's very close to the Sun



If all of these types of energy from the Sun are always shining down on Earth, how does the Earth manage to maintain the perfect balance of energy – or equilibrium – that allows us to live and survive on Earth?


Average Surface Temperature -  
65 C (~85 F)

The planet Mars – “too cold” because it is farther from the Sun and has a very thin atmosphere.

thin atmosphere.

is farther from the sun and has a very






If all of these types of energy from the Sun are always shining down on Earth, how does the Earth manage to maintain the perfect balance of energy – or equilibrium – that allows us to live and survive on Earth?

Average Surface Temperature -  
18 C (~64 F)

3<sup>rd</sup> rock from the Sun. Still too cold for life.

1<sup>st</sup>  
3<sup>rd</sup> rock from the Sun. Still too cold for



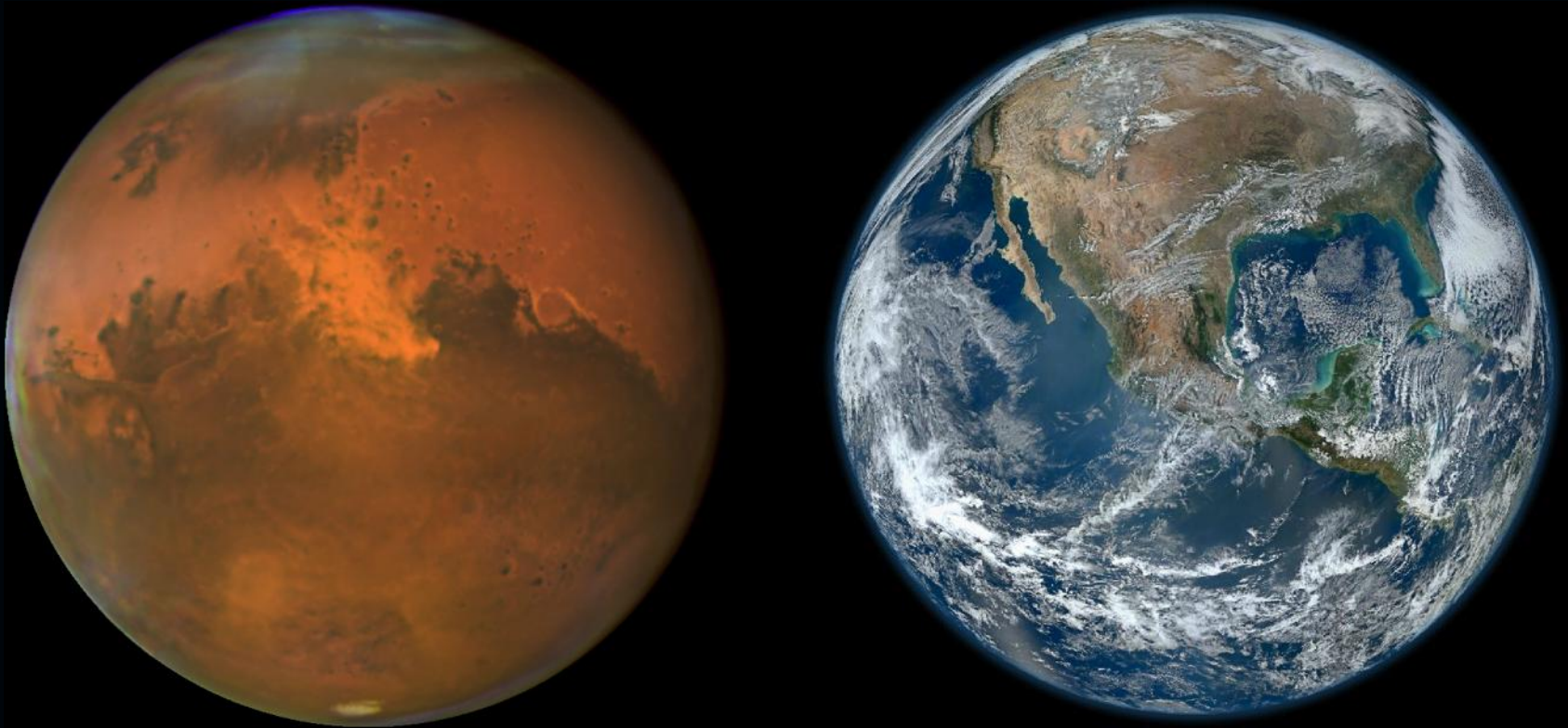
If all of these types of energy from the Sun are always shining down on Earth, how does the Earth manage to maintain the perfect balance of energy – or equilibrium – that allows us to live and survive on Earth?

Average Surface Temperature  
15 C (~59F)

The planet Earth with its atmosphere – just the right balance for life to survive and thrive.

and thrive.

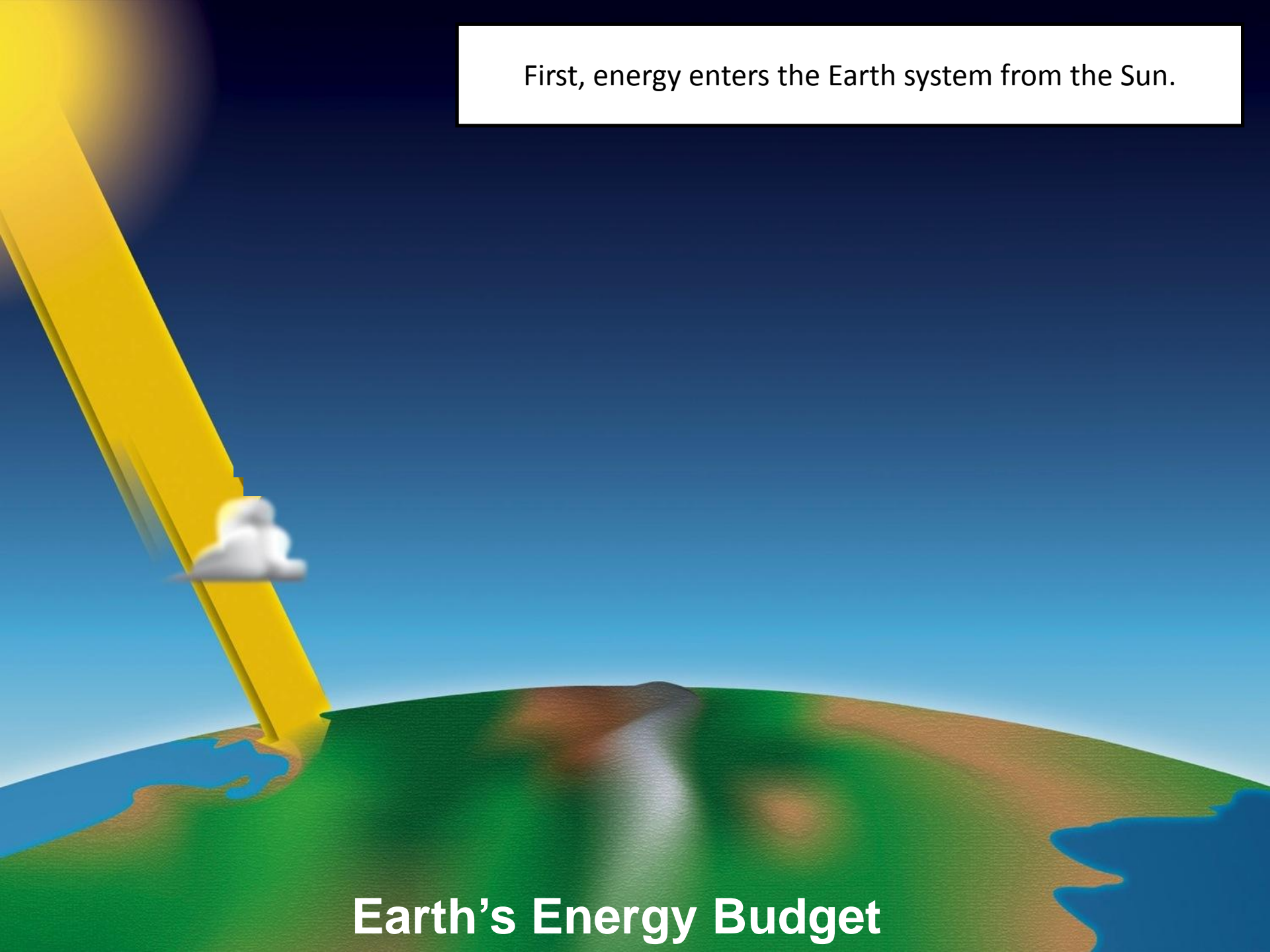
just the right balance for life to survive



The temperatures of Earth and all the planets are determined by their "Energy Budget."

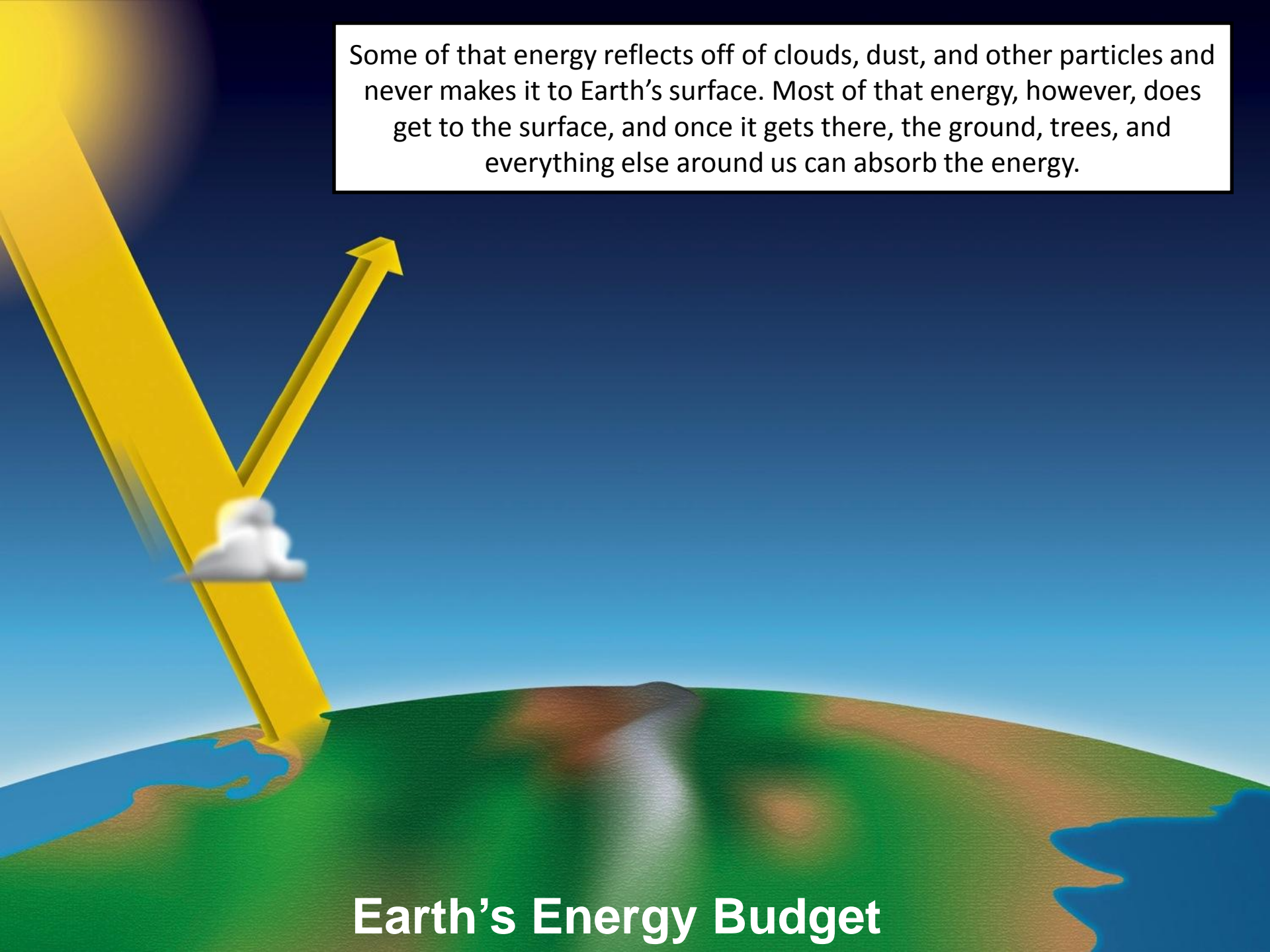


First, energy enters the Earth system from the Sun.



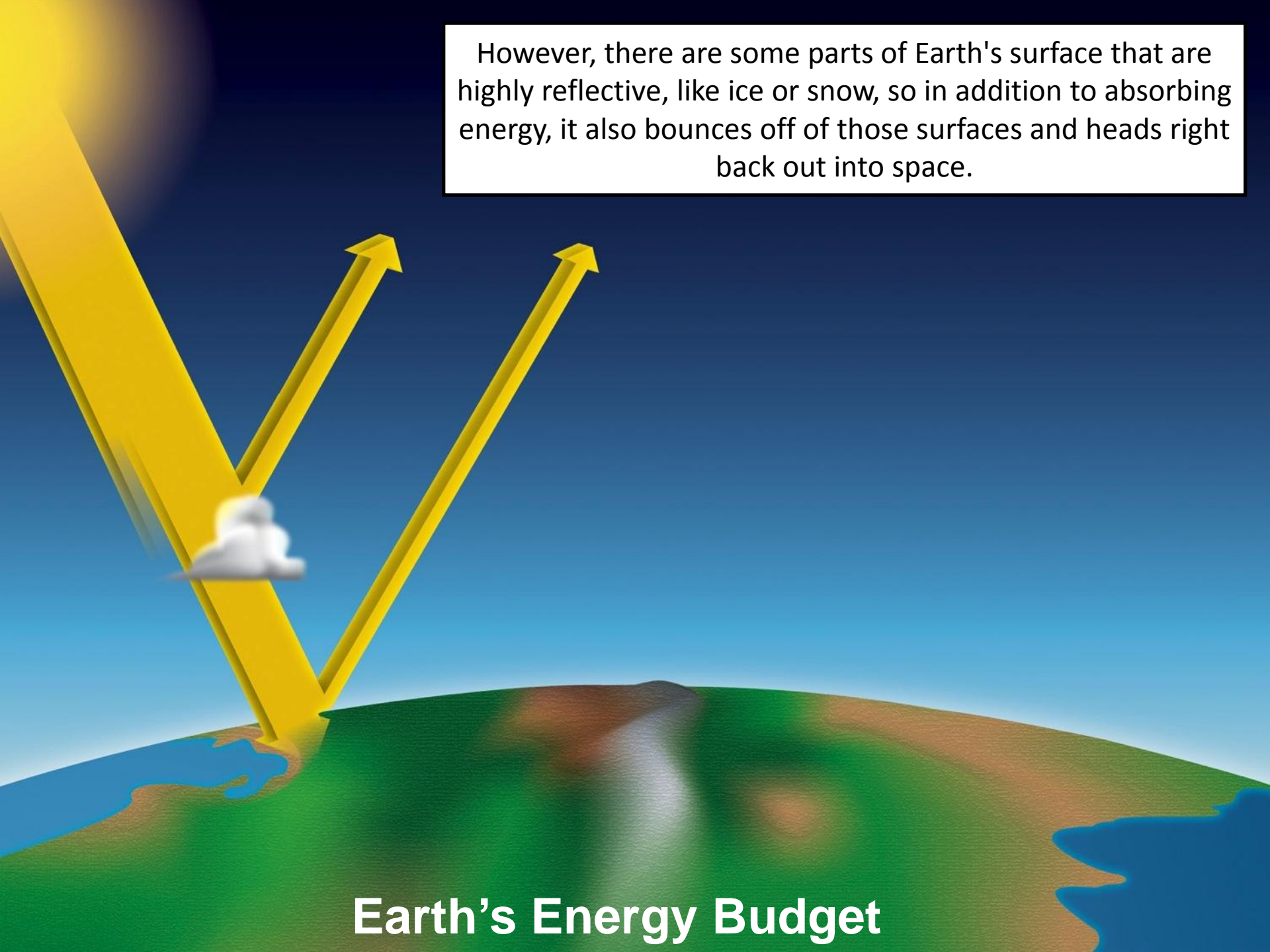
## Earth's Energy Budget

Some of that energy reflects off of clouds, dust, and other particles and never makes it to Earth's surface. Most of that energy, however, does get to the surface, and once it gets there, the ground, trees, and everything else around us can absorb the energy.



**Earth's Energy Budget**

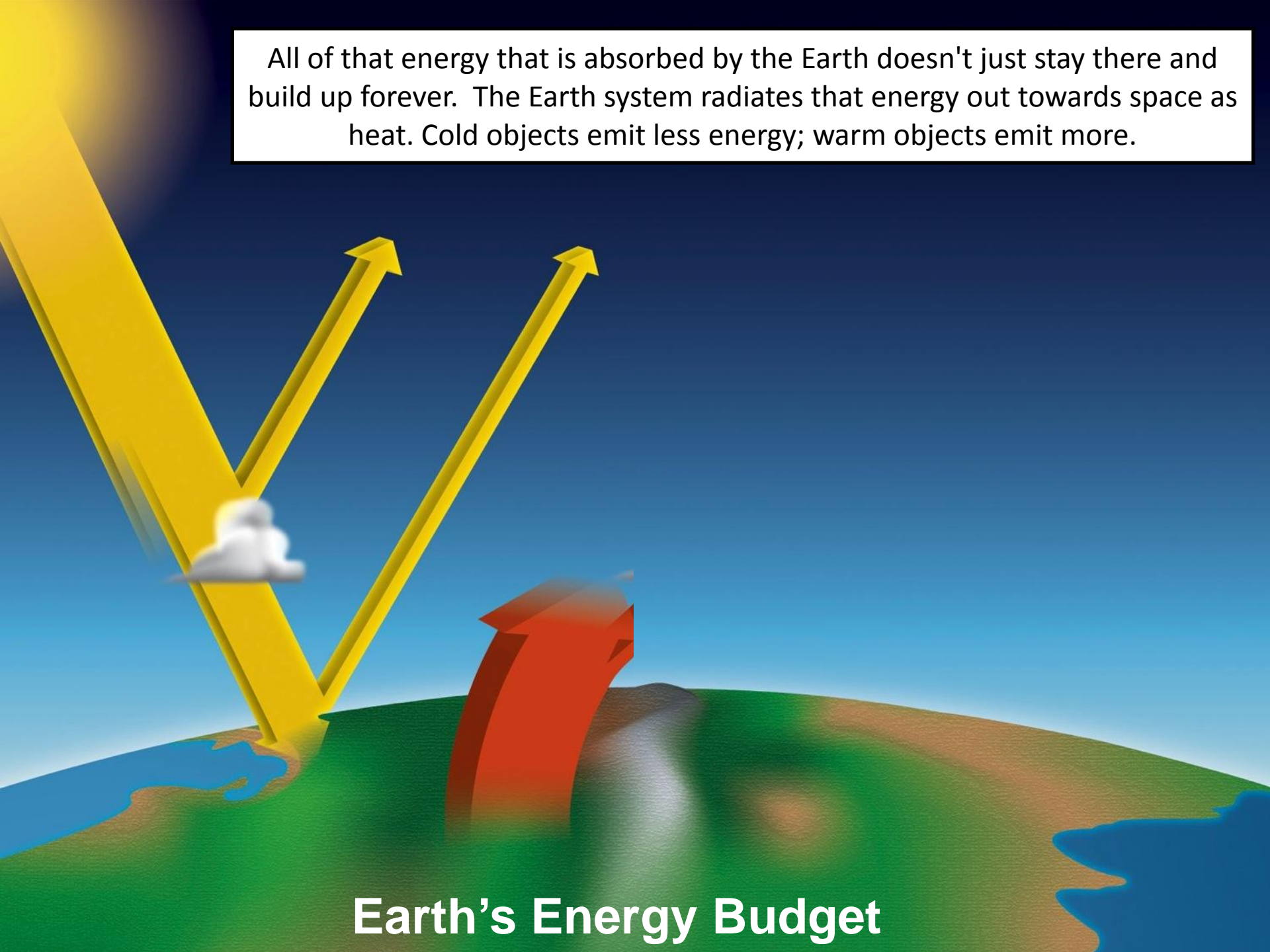
However, there are some parts of Earth's surface that are highly reflective, like ice or snow, so in addition to absorbing energy, it also bounces off of those surfaces and heads right back out into space.



**Earth's Energy Budget**

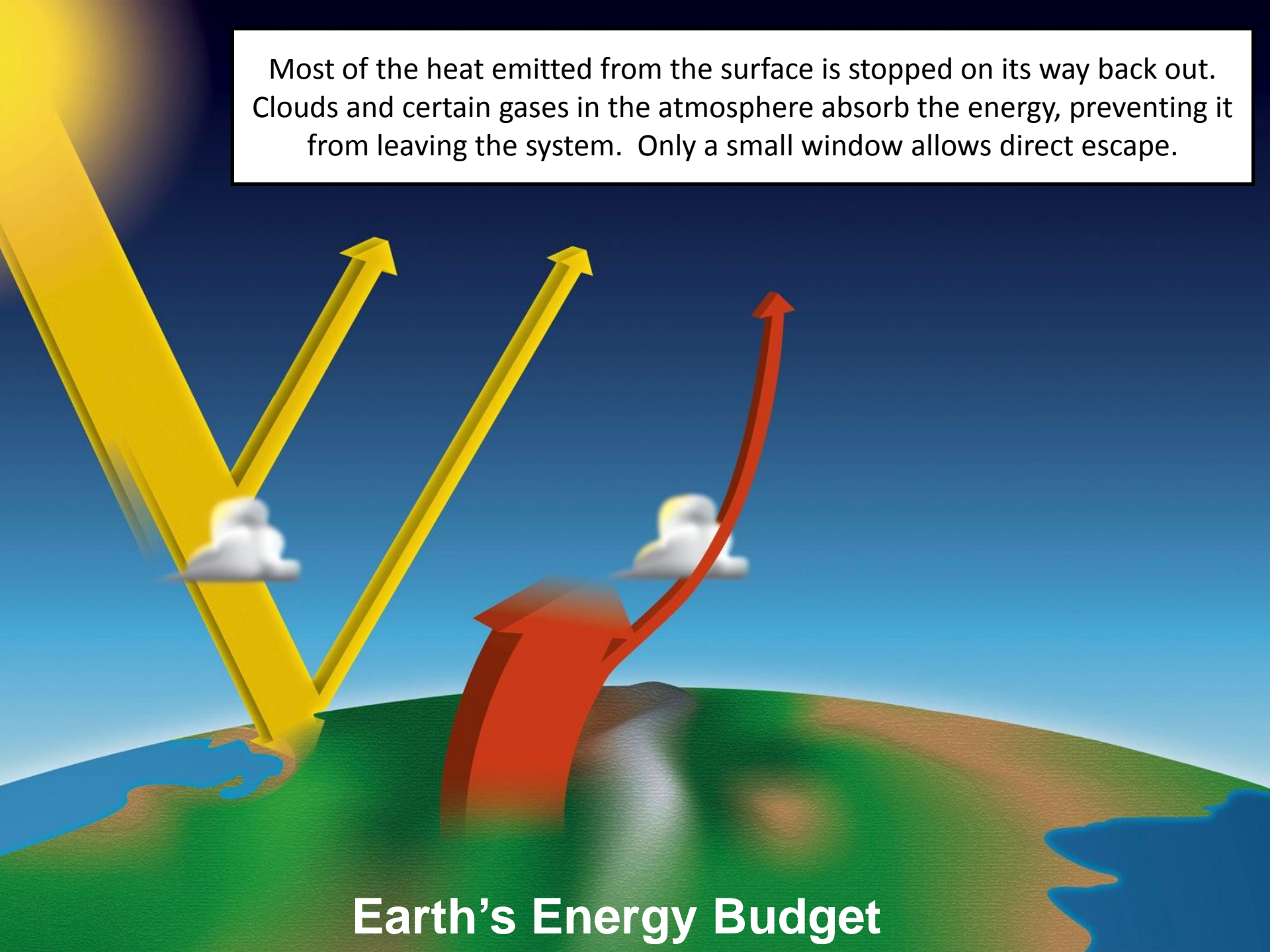


All of that energy that is absorbed by the Earth doesn't just stay there and build up forever. The Earth system radiates that energy out towards space as heat. Cold objects emit less energy; warm objects emit more.



**Earth's Energy Budget**

Most of the heat emitted from the surface is stopped on its way back out. Clouds and certain gases in the atmosphere absorb the energy, preventing it from leaving the system. Only a small window allows direct escape.



**Earth's Energy Budget**

Energy emitted from those clouds and gases goes in all directions. Some comes back to further warm the Earth. This is the greenhouse effect.



**Earth's Energy Budget**



Finally, the surface energy budget is balanced by thermals and evaporation.



**Earth's Energy Budget**

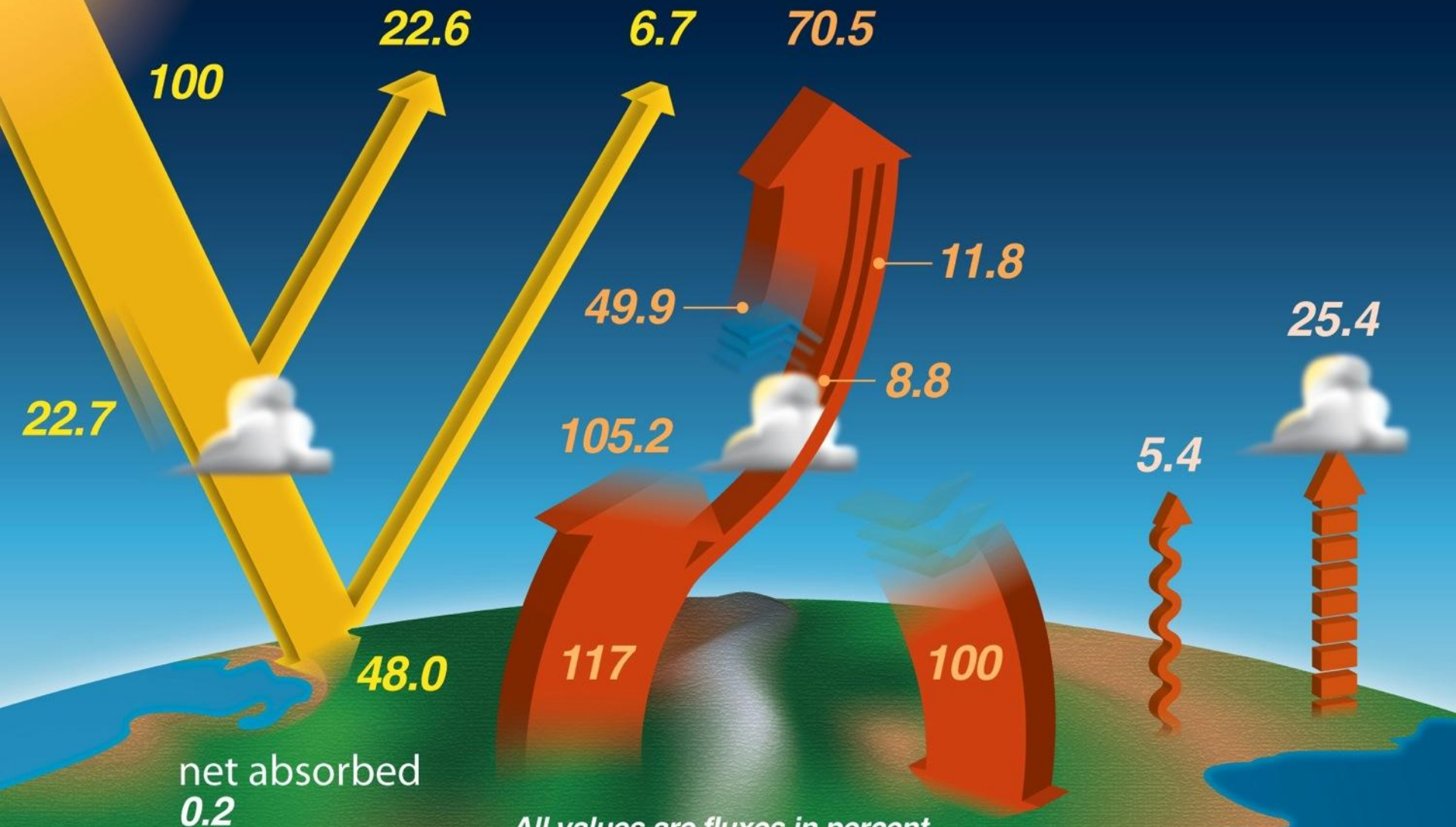
Together all of these forms of incoming and outgoing energy have resulted in just the right living conditions for us on Earth.



**Earth's Energy Budget**



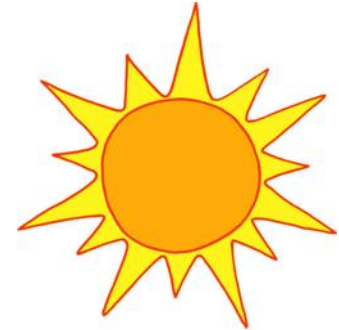
Scientists use satellites, ground-based instruments, aircraft field campaigns, and computer models to determine the magnitude of each flux.



All values are fluxes in percent  
and are average values based on ten years of data

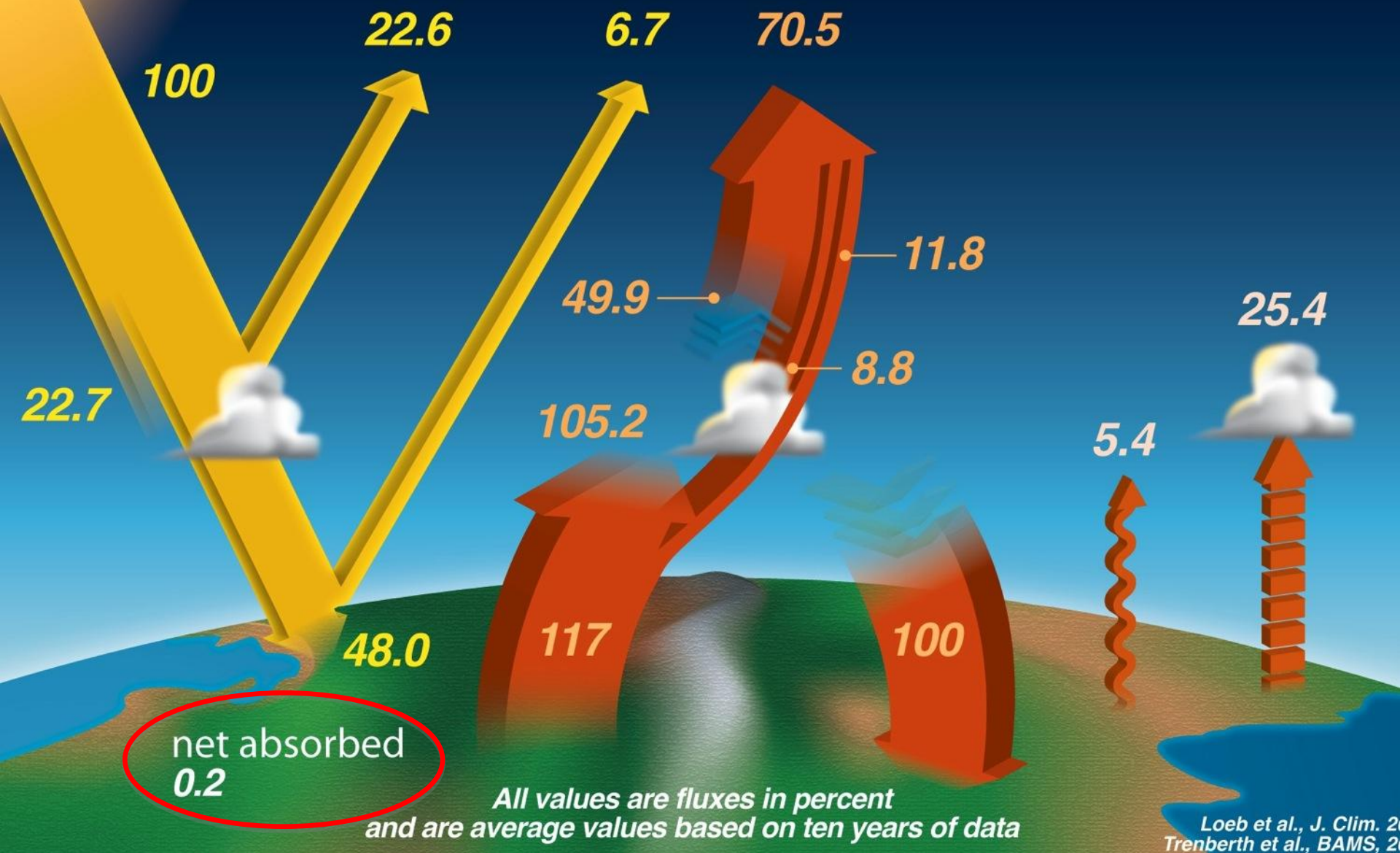
Loeb et al., J. Clim. 20  
Trenberth et al., BAMS, 20



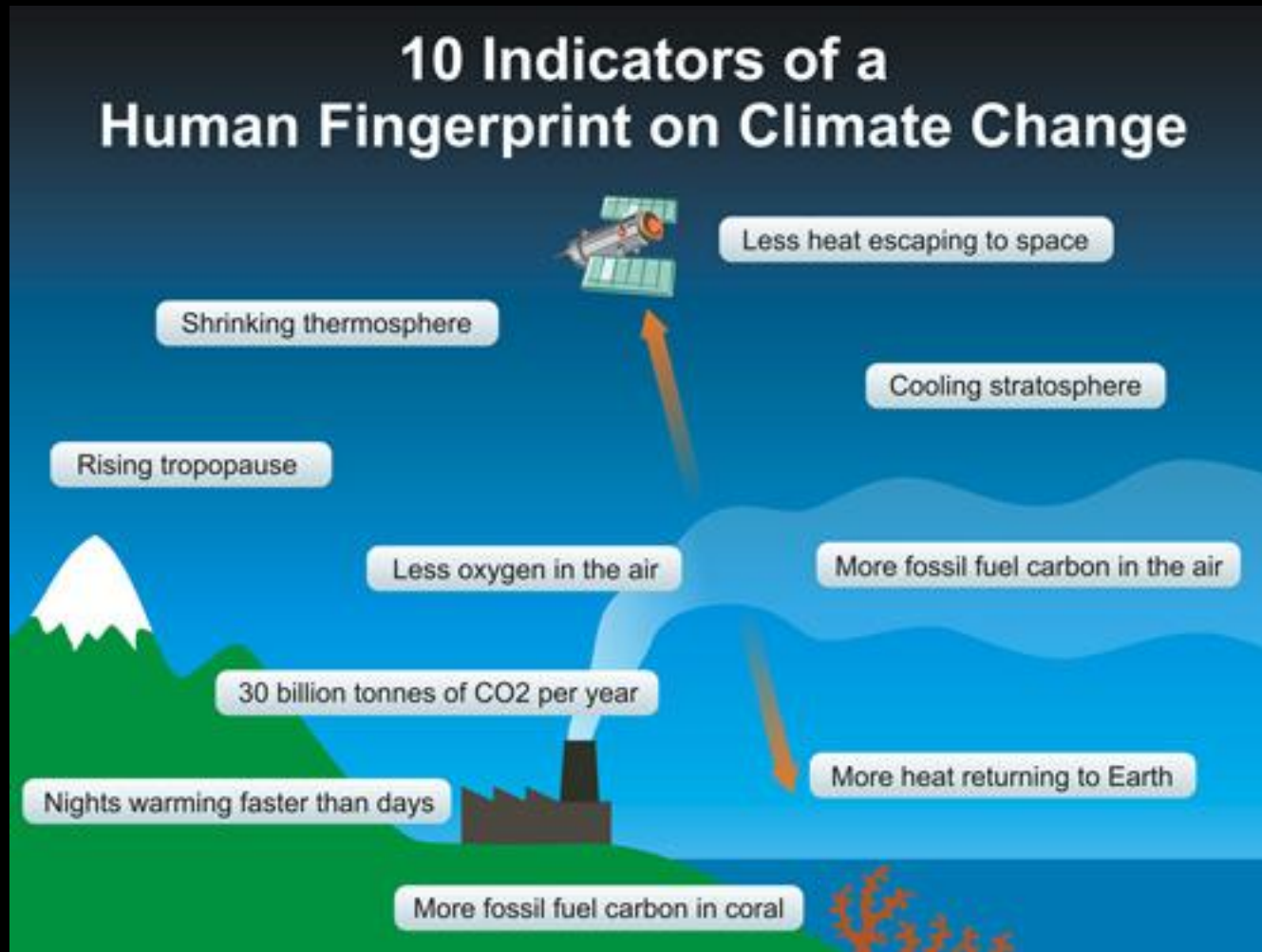


Like your house, anything that increases or decreases the amount of incoming or outgoing energy would disturb Earth's energy balance and would cause global temperatures to rise or fall.

Over the last decade, our best estimate is that there is a small positive imbalance in Earth's energy budget.



This is consistent with several other *lines of evidence* of a warming planet.





The End  
... for now

Details behind the story

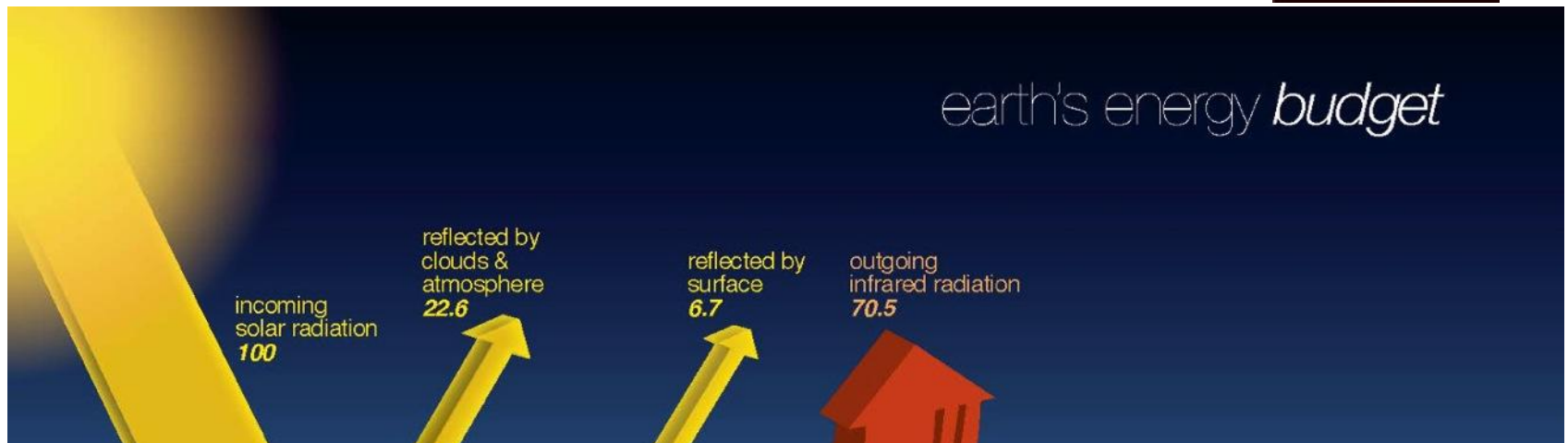
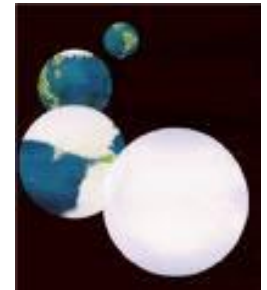
# Balancing the Budget - I

At the **top of the atmosphere:**

- + Sunlight In
  - Sunlight reflected from clouds/atmosphere
  - Sunlight reflected from surface
  - IR emission
- 

0?

**Equilibrium  
Temperature:  
-18 °C**



[http://mynasadata.larc.nasa.gov/preview\\_lesson.php?&passid=44](http://mynasadata.larc.nasa.gov/preview_lesson.php?&passid=44)



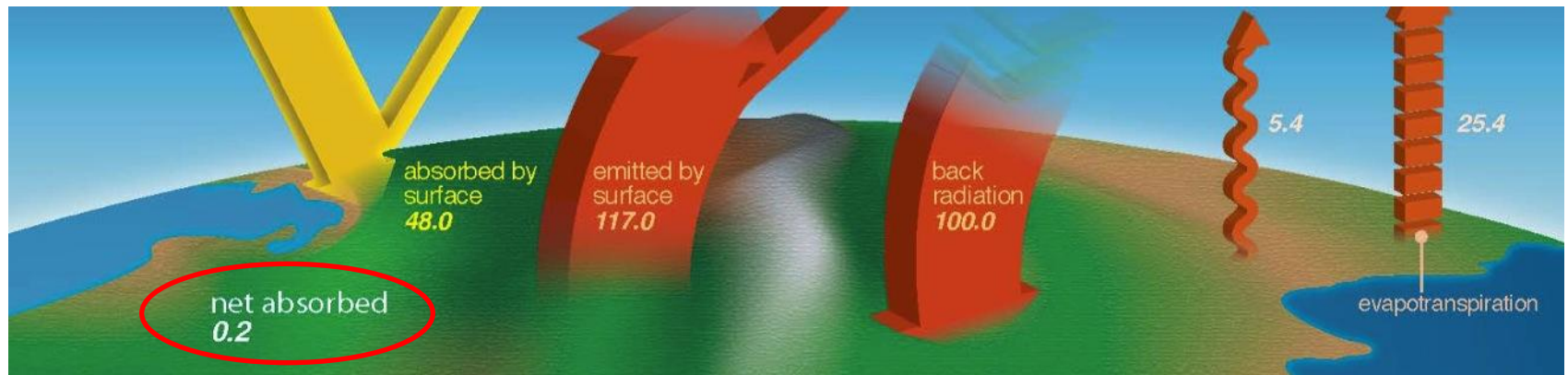
# Balancing the Budget - II

At the **Earth's surface**:

- + Sunlight absorbed
- IR emission
- + IR back radiation (greenhouse effect)
- Thermals
- Evapotranspiration

0?

**Equilibrium  
Temperature:  
15 °C**



[http://mynasadata.larc.nasa.gov/preview\\_lesson.php?&passid=63](http://mynasadata.larc.nasa.gov/preview_lesson.php?&passid=63)

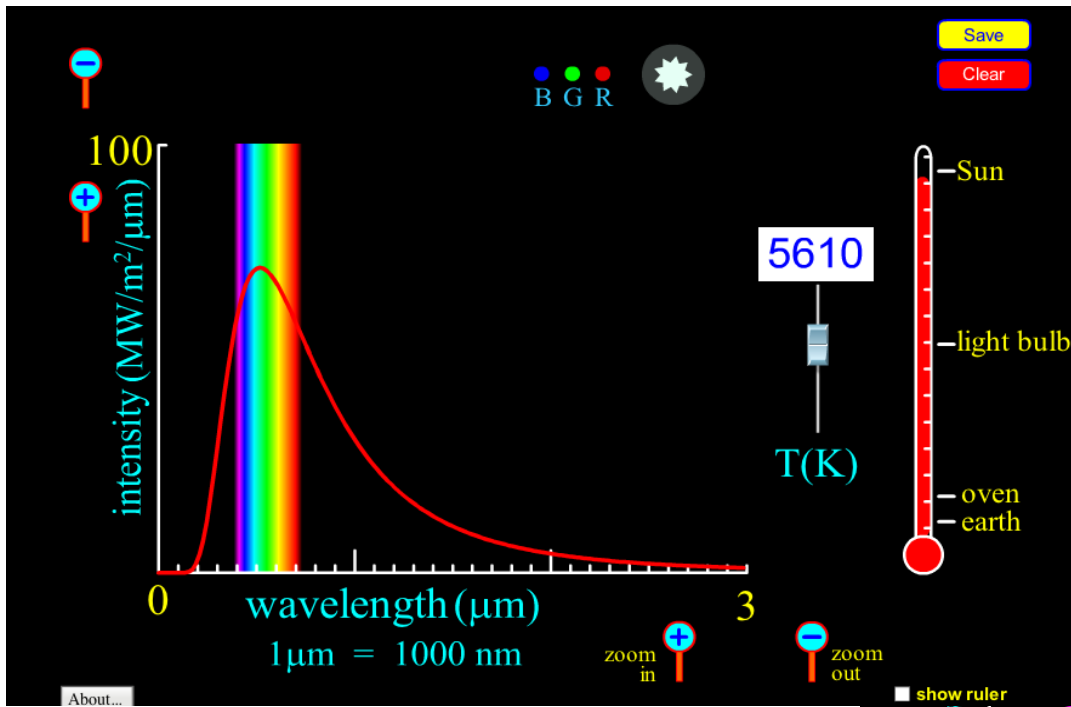
[http://mynasadata.larc.nasa.gov/preview\\_lesson.php?&passid=67](http://mynasadata.larc.nasa.gov/preview_lesson.php?&passid=67)

# Greenhouse Effect

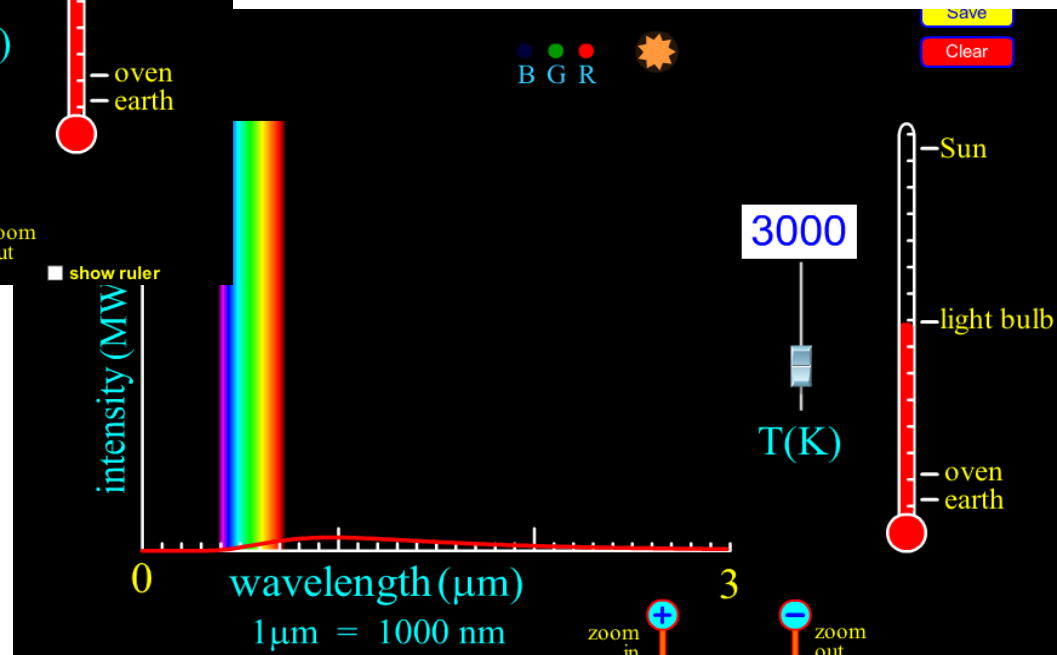


<http://www.youtube.com/watch?v=b3NFfWlfj24>

# The Blackbody Spectrum



Every object emits energy according to its temperature. Hotter objects (like the Sun) emit lots of energy at mostly shorter wavelengths (visible); cooler objects (like the Earth) emit less energy at longer wavelengths (infrared).

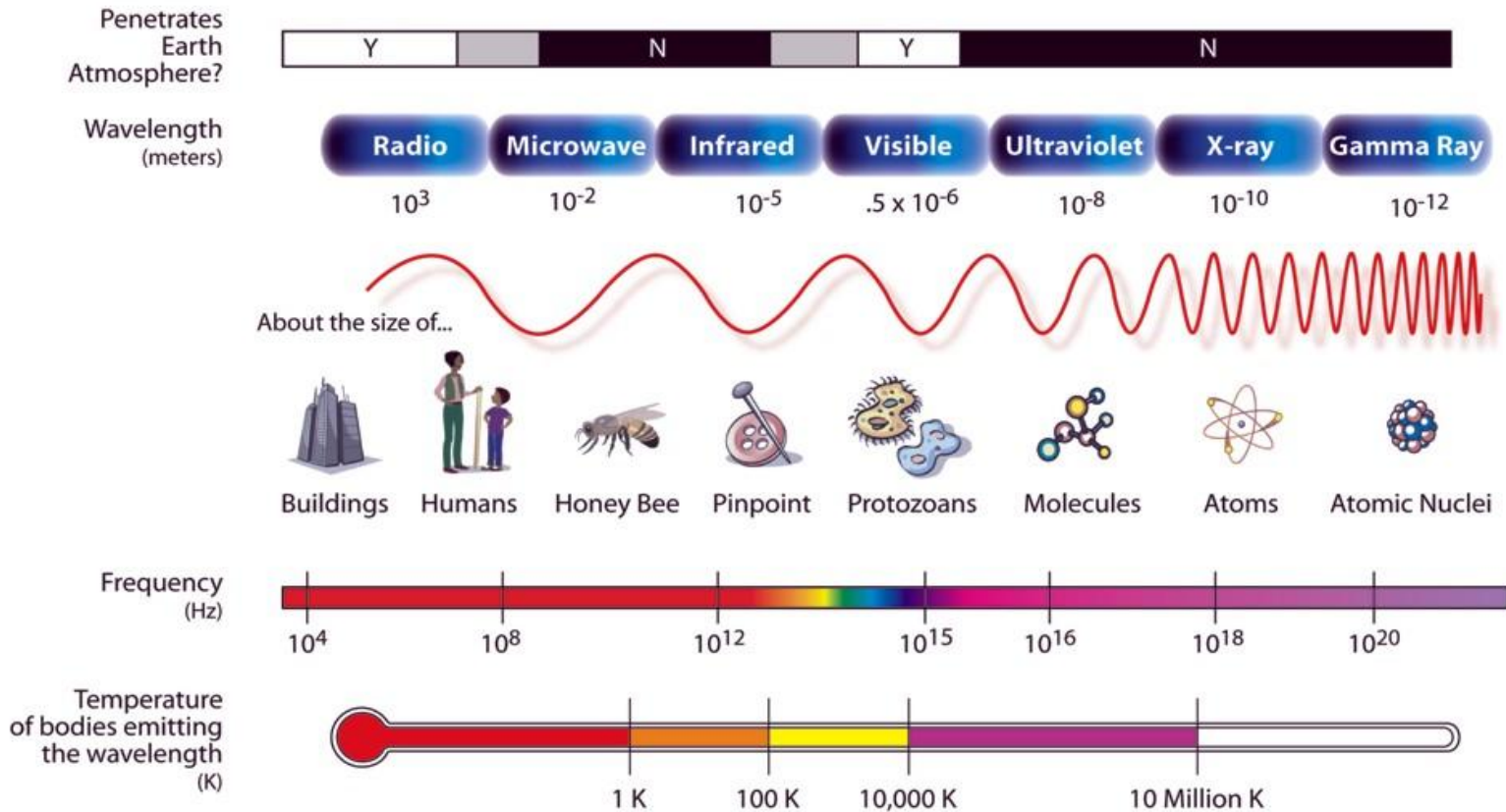


[http://phet.colorado.edu/simulations/sims.php?sim=Blackbody\\_Spectrum](http://phet.colorado.edu/simulations/sims.php?sim=Blackbody_Spectrum)



# The Electromagnetic Spectrum

## THE ELECTROMAGNETIC SPECTRUM



<http://mynasadata.larc.nasa.gov/ElectroMag.html>

# Access to Data – MY NASA DATA

- Interactive access to energy budget data for classroom exploration
- Peer-reviewed lesson plans
- Science project ideas
- Science glossary

The screenshot shows the MY NASA DATA website. At the top is a banner with the logo and the tagline "Mentoring and inquiry using NASA Data on Atmospheric and earth science for Teachers and Amateurs". Below the banner is a navigation menu with links: Home, Live Access Server, Lesson Plans, Data Sources, Mission, Mission Support, Observe Your World, Conferences, and Meet the Team. A search bar is located at the top right. The main content area features a large section titled "MY NASA DATA" with a grid of colored buttons for "Educators", "Students", "Citizen Scientists", "Researchers", and "Using My NASA Data". To the right of this grid is a globe and a small inset showing a world map and a data graph. Below the grid is a large image of a satellite with the text "Over 200 Data Sets that will fit into any Science Classroom!" and a prompt "Don't see what you're looking for? Suggest a parameter". To the right of the satellite image is a sidebar titled "NSTA WEB SEMINARS" with a link to "MY NASA DATA Webinar for Educators: Analyzing Solar Energy Graphs (March 26)". At the bottom of the page are four buttons: "Photos", "Connect", "Apps", and "Contact".

<http://mynasadata.larc.nasa.gov/>

# Access to Data



MY NASA DATA Home Intermediate LAS Basic LAS

## MY NASA DATA Live Access Server - Advanced

[Choose dataset](#) [Update Plot](#) [Set plot options](#) [Animate](#) [Compare](#) [Google Earth](#) [Show Values](#) [Export to Desktop](#)


[Link To ...](#) [Print](#)

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**Welcome to *Live Access Server*.**

To begin, click the **"Choose dataset"** button.





# Access to Data

## Datasets

### ☒ Atmosphere

#### ☒ Atmospheric Radiation

##### ☒ Surface

- ☐ Daily Surface All-sky LW Downward Flux (SRB)
- ☐ Daily Surface All-sky LW Upward Flux (SRB)
- ☐ Daily Surface All-sky SW Downward Flux (SRB)
- ☐ Daily Surface All-sky SW Upward Flux (SRB)
- ☐ Daily Surface Clear-sky SW Downward Flux (SRB)
- ☐ Daily Surface Clear-sky SW Upward Flux (SRB)
- ☐ Daily Surface Clear-sky LW Downward Flux (SRB)
- ☐ Daily Surface Clear-sky LW Upward Flux (SRB)
- ☐ Monthly Surface All-sky LW Upward Flux (SRB)
- ☐ Monthly Surface All-sky LW Downward Flux (SRB)
- ☐ Monthly Surface Clear-sky LW Upward Flux (SRB)
- ☐ Monthly Surface Clear-sky LW Downward Flux (SRB)
- ☐ Monthly Surface Clear-sky SW Downward Flux (SRB)
- ☐ Monthly Surface Clear-sky SW Upward Flux (SRB)
- ☐ Monthly Surface All-sky PAR Flux (SRB)
- ☒ Monthly Surface All-sky SW Downward Flux (SRB)
- ☐ Monthly Surface All-sky SW Upward Flux (SRB)

##### ☒ Top of Atmosphere (TOA) All Sky

##### ☒ Top of Atmosphere (TOA) Clear Sky

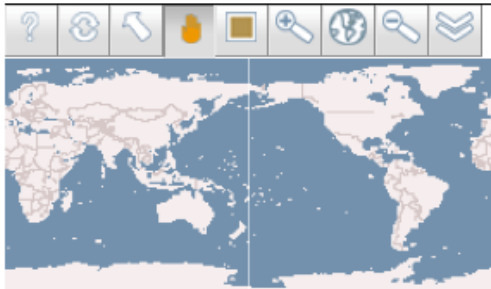
### ☒ Biosphere

### ☒ Cryosphere

# Access to Data

? Atmospheric Radiation / Surface

+ Monthly Surface All-sky SW Downward Flux (SRB)



90 N  
0 E 0 E  
90 S

## MAPS

☒ Latitude-Longitude

## HOVMOLLER PLOTS

☐ Longitude-Time

☐ Latitude-Time

## LINE PLOTS

☐ Time Series

☐ Longitude

☐ Latitude

## SCATTER PLOTS

☐ Property-Property

Date:

Jul 1983

Apply analysis

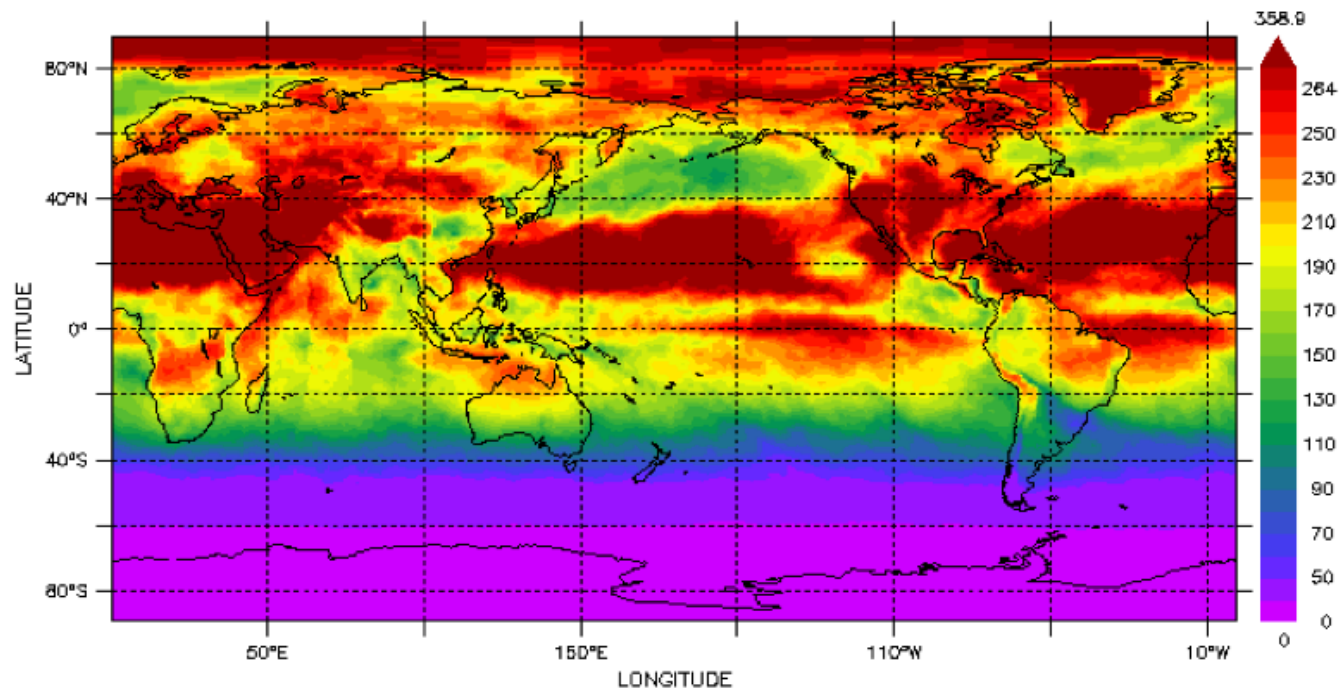
Earth's Energy Budget

LAS 7./Ferret 6.71

NOAA/PMEL

TIME : 01-JUL-1983 00:00

DATA SET: Surface

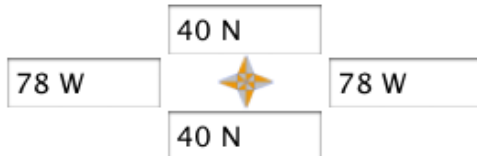
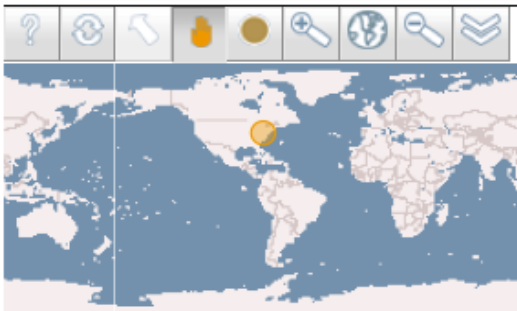


Monthly Surface All-sky SW Downward Flux (SRB) ( $\text{W m}^{-2}$ )

# Access to Data

? Atmospheric Radiation / Surface

+ Monthly Surface All-sky SW Downward Flux (SRB)



## MAPS

☐ Latitude-Longitude

## HOVMOLLER PLOTS

☐ Longitude-Time

☐ Latitude-Time

## LINE PLOTS

☒ Time Series

☐ Longitude

☐ Latitude

## SCATTER PLOTS

☐ Property-Property

Date Range:

Jul 1983

Jun 2007

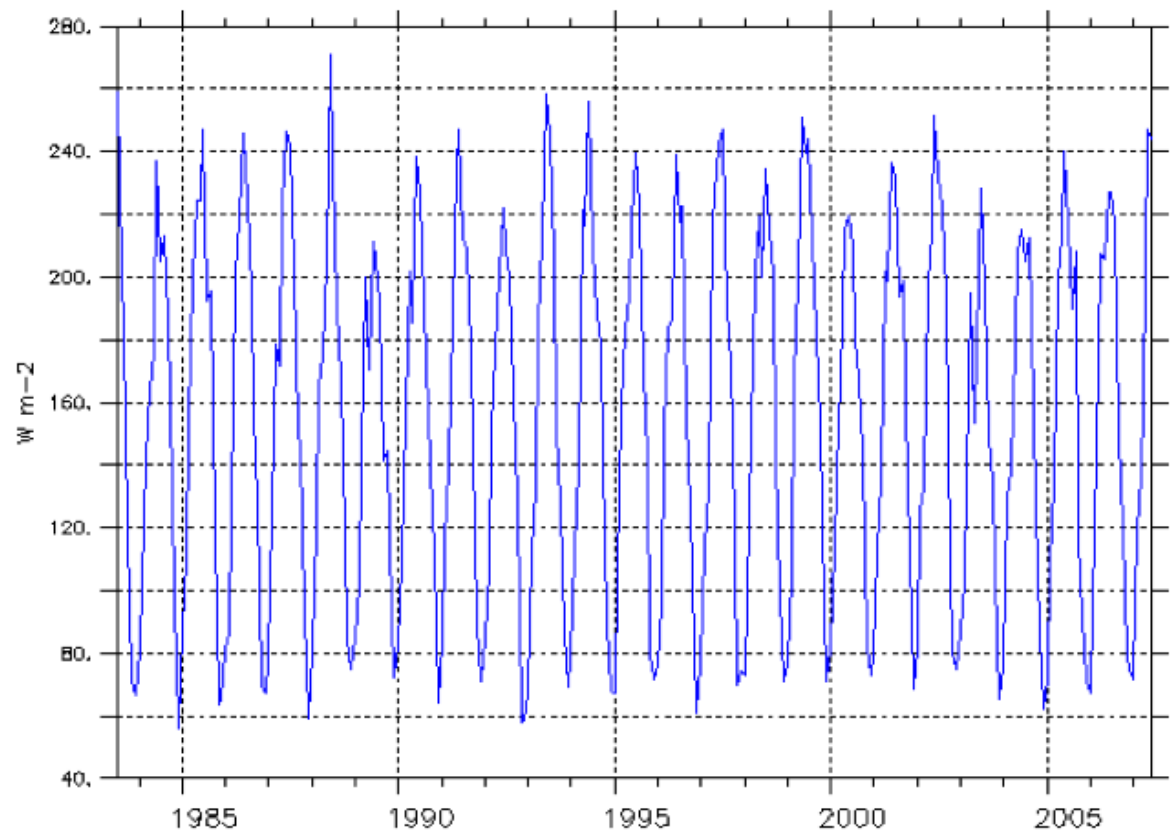
LAS 7./Ferret 6.71

NOAA/PMEL

LONGITUDE : 78.5W(-78.5)

LATITUDE : 39.5N

DATA SET: Surface



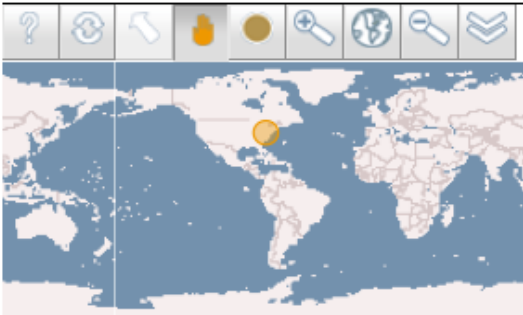
Monthly Surface All-sky SW Downward Flux (SRB) ( $\text{W m}^{-2}$ )



# Access to Data

? Atmospheric Radiation / Surface

+ Monthly Surface All-sky SW Downward Flux (SRB)



40 N  
78 W 78 W  
40 N

## MAPS

☐ Latitude-Longitude

## HOVMOLLER PLOTS

☐ Longitude-Time

☐ Latitude-Time

## LINE PLOTS

☒ Time Series

☐ Longitude

☐ Latitude

## SCATTER PLOTS

☐ Property-Property

Date Range:

Jun 2006

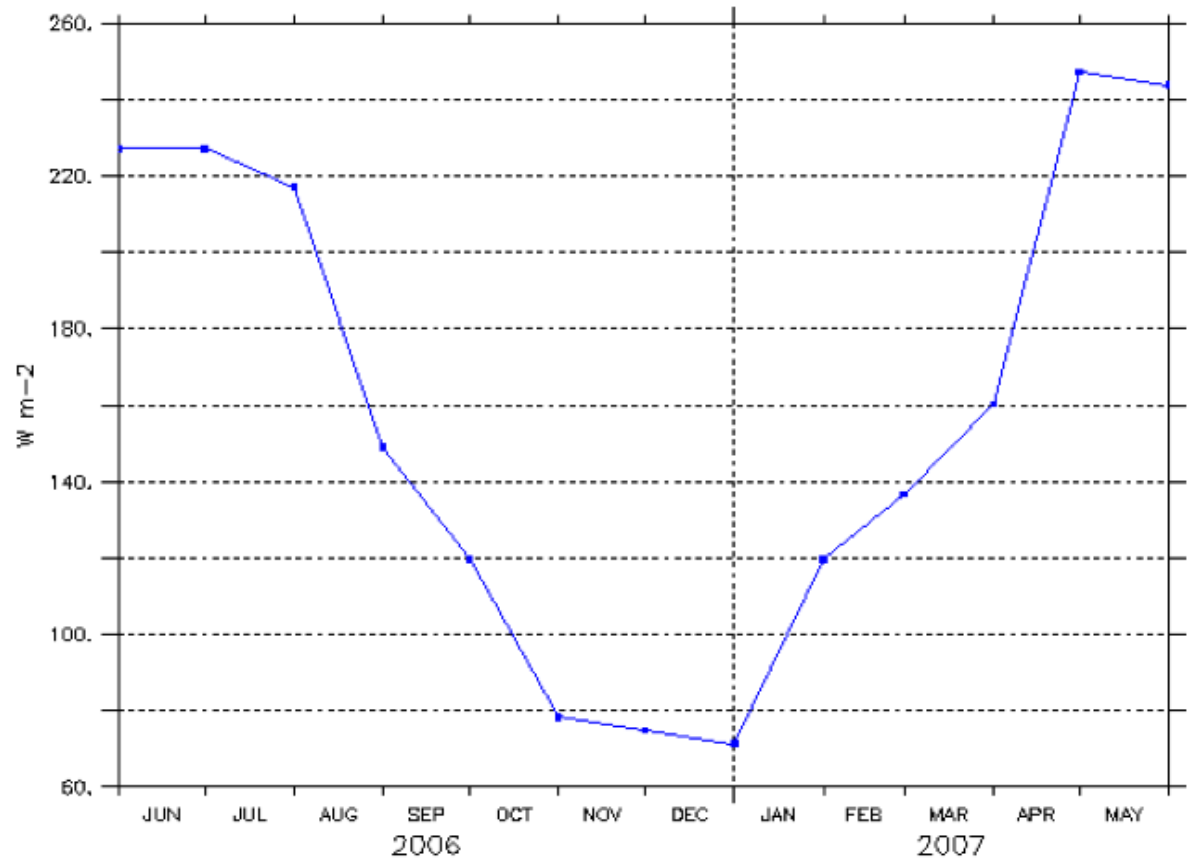
Jun 2007

LAS 7./Ferret 6.71

NOAA/PMEL

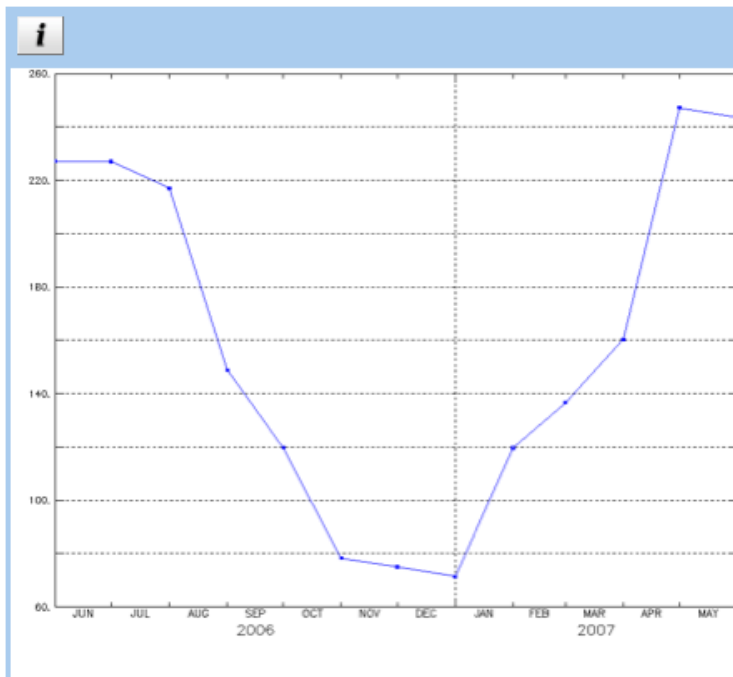
LONGITUDE : 78.5W(-78.5)  
LATITUDE : 39.5N

DATA SET: Surface

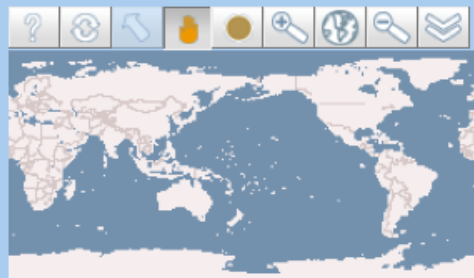


Monthly Surface All-sky SW Downward Flux (SRB) ( $\text{W m}^{-2}$ )

# Access to Data



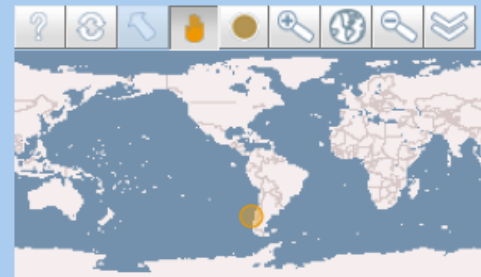
▼ Comparison Axis



40 N  
78 W 40 N  
78 W



▼ Comparison Axis



40 S  
78 W 40 S  
78 W